ORDER

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

8400.12A

2/9/98

SUBJ: REQUIRED NAVIGATION PERFORMANCE 10 (RNP-10) OPERATIONAL APPROVAL

1. PURPOSE. The purpose of this Order is to provide policy and direction for obtaining operational approval of Required Navigation Performance 10 (RNP-10) capability. Guidance on airworthiness, continuing airworthiness, and RNP-10 operational approval are provided. The order enables an applicant to be approved as capable of meeting the NAVIGATION ELEMENT requirements when RNP-10 is specified. The order does not address communications or surveillance requirements that may be specified to operate on a particular route or in a particular area. Those requirements are specified in other documents such as Aeronautical Information Publications (AIP) and the International Civil Aviation Organization (ICAO) Regional Supplementary Procedures Document (DOC 7030).

2. DISTRIBUTION. This order is distributed to the director level in Washington headquarters and the Centers; to all regional administrators; to the branch level in the Flight Standards Service, and Aircraft Certification Service; to the branch level in the regional Flight Standards divisions, and Aircraft Certification directorates; to all regional International Aviation Officers; to all Flight Standards, Aircraft Certification, and International Aviation field offices.

3. CANCELLATION. FAA Order 8400.12, dated January 24, 1997, is canceled.

4. BACKGROUND.

a. States and operators are beginning implementation of RNP as part of a worldwide ICAO effort to implement the Future Air Navigation Systems (FANS), Communication/Navigation/Surveillance (CNS) and Air Traffic Management (ATM) concept. To support this effort, the Informal Pacific Air Traffic Service Coordination Group (IPACG) has developed plans to implement 50 Nautical Mile (NM) lateral separation on the North Pacific (NOPAC) and Central East Pacific (CEPAC) routes based on approval of an RNP-10 capability for the total route of the flight. In accordance with ICAO coordinated regional agreements, operators will be required to obtain approval to the RNP-10 criteria, or equivalent criteria developed by the operator's state of registry. This performance capability requirement is similar to the existing Minimum Navigation Performance Specification (MNPS) over the Atlantic.

b. Following the implementation of 50 NM lateral separation based upon an RNP-10 capability, additional separation reductions based on more stringent parameters will be implemented. The implementation of more stringent RNP capability, as well as other CNS elements, is part of a worldwide ICAO coordinated effort to improve ATM and CNS services. This first step is necessary to provide early benefits to users in terms of efficient use of airspace, more optimum routings, reduced delay, increased traffic flow capacity, increased flexibility, reduced costs, appropriately adjusted aircraft to aircraft separation standards and increased safety.

5. RELATED PUBLICATIONS.

a. FAA Documents.

(1) 14 CFR Part 121, Appendix G.

(2) Advisory Circular (AC) 20-130, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors, latest edition.

(3) AC 20-138, Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use as a VFR and IFR Supplemental Navigation System, latest edition.

(4) FAA Order 7110.82, Monitoring of Navigation/Altitude Performance in Oceanic Airspace, latest edition.

(5) FAA Order 8400.10, Air Transportation Operations Inspector's Handbook.

(6) FAA Order 8700.1, General Aviation Operations Inspector's Handbook.

(7) Handbook Bulletin for Air Transportation (HBAT) 95-09, Guidelines for Operational Approval of Global Positioning System [GPS] to Provide the Primary Means of Class II Navigation in Oceanic and Remote Areas of Operation.

b. Other Documents.

(1) Copies of the following may be obtained from Document Sales Unit, ICAO, 999 University Street, Montreal, Quebec, Canada H3C 5H7:

(a) Manual on Required Navigation Performance (RNP), ICAO DOC 9613-AN/937.

(b) Asia Pacific Guidance Material for RNAV Operations.

(2) Copies of the following may be purchased from NOAA, N/ACC3, Distribution Division, Riverdale, MD 20737:

(a) United States Government Flight Information Publication - Chart Supplement - Alaska.

(b) United States Government Flight Information Publication - Chart Supplement - Pacific.

(3) Copies of Minimum Aviation System Performance Standards (MASPS): Required Navigation Performance for Area Navigation, RTCA, may be purchased from RTCA, Inc., 1140 Connecticut Avenue, NW., Suite 1020, Washington, DC 20036.

(4) Copies of Aeronautical Information Manual (AIM) may be purchased from the U.S. Government Printing Office, P.O. Box 371954, Pittsburgh, PA 15250-7954.

6. APPLICABILITY.

a. This guidance applies to all operators conducting operations under Title 14 of the Code of Federal Regulations (14 CFR) parts 91, 121, 125, and 135.

b. The requirements are consistent with 14 CFR part 91, sections 91.703(a)(1) and (a)(2), which require each certificate holder, operating a civil aircraft of U.S. registry outside of the United States, to comply with ICAO, Annex 2, when over the high seas, and to comply with the regulations of a foreign country when operating within that country's airspace.

7. OPERATIONAL APPROVAL.

a. General. To obtain operational approval, aircraft eligibility must be determined, appropriate flightcrew procedures for the navigation systems to be used must be identified by the applicant (e.g., Class II Nav procedures); and database use and operating procedures must be evaluated, if applicable. Then appropriate operations specifications or a letter of authorization (LOA) may be issued, as applicable to the operator.

b. Approved Aircraft/System List. The Federal Aviation Administration (FAA) Technical Programs Division, AFS-400, will maintain a list of aircraft/navigation systems that have received approval. This list will be maintained for informational, statistical, and training purposes. The list IS NOT USED as a means of determining qualifications for approval, but may serve as a guideline to field offices and operators to note those aircraft and navigation systems which have been approved.

8. OPERATIONAL APPROVAL PROCESS. RNP-10 requires that each individual aircraft must be determined to be qualified, and the individual operator must be approved by appropriate FAA offices before the operator conducts flight in RNP-10 airspace. This Order provides guidance for the approval of operators for flight in airspace where RNP-10 is applied, and provides guidance on aircraft certification where RNP-10 eligibility cannot otherwise be determined, or where the operator chooses to lengthen RNP-10 approval time limits. The following paragraphs provide application guidelines for operators desiring to obtain RNP-10 operational approvals. Appendix 5 is a combined operator's and inspector's Job Aid that provides a concise summary of the steps required to complete the approval process.

a. Preapplication Meeting. Each individual operator should schedule a preapplication meeting with either the certificate holding district office (CHDO) or the Flight Standards district office (FSDO). The intent of this meeting is to inform the operator of FAA expectations in regard to approval to operate in an RNP-10 airspace for a specified length of time; to discuss the contents of the operator's application; for the FAA to review and evaluate the application; and to discuss conditions for removal of the operational approval.

b. Operators seeking RNP-10 operational approval should contact FAA offices as follows:

(1) Parts 121, 125, and 135 Operators. These operators should notify the Certificate Management Office (CMO) or CHDO which holds its operating certificate of its intent to request approval for RNP-10 operations. RNP-10 authorizations for air carriers will be addressed through issuance of approved operations specifications. The operations specifications will identify any conditions or limitations necessary (e.g., navigation systems or procedures required, time limits, routes or areas authorized). A sample letter of request for an air carrier to obtain RNP-10 operational approval is provided in Appendix 3, figure 1.

(2) Part 91 Operators. These operators should contact their local FSDO to start the process for RNP-10 authorization. Operators under part 91 will receive an LOA, which authorizes RNP-10 operations. The LOA will identify any conditions or limitations necessary (e.g., navigation systems or procedures required, time limits, routes or areas authorized). A sample letter of request for a general aviation operator to obtain RNP operational approval and the resulting LOA are provided in Appendix 3, figure 2.

c. Determining Eligibility and Approval of Aircraft for RNP-10. Many aircraft and navigation system types currently in use in oceanic or remote area operations will qualify for RNP-10 based on one or more provisions of existing certification criteria. Thus, additional aircraft certification action may not be necessary for the majority of RNP-10 approvals. In these instances, additional aircraft certification will only be necessary if the operator chooses to claim additional performance beyond that originally certified or stated in the Airplane Flight Manual (AFM) and if the operator cannot demonstrate the desired performance through data collection.

9. APPLICATION.

a. Contents of Operator's RNP-10 Application.

(1) Eligibility Airworthiness Documents. Sufficient documentation should be available to establish that the aircraft has an appropriate AFM, AFM Supplement (AFMS), if applicable, and is otherwise suitably qualified to fly the intended routes (e.g., long-range navigation, communication).

(2) Description of Aircraft Equipment. The applicant should provide a configuration list which details pertinent components and equipment to be used for long range navigation and RNP-10 operations.

(3) RNP-10 Time Limit for Inertial Navigation Systems (INS) or Inertial Reference Units (IRU) (if applicable). The RNP-10 time limit for which the applicant's INS or IRU system have been approved should be provided (see paragraph 12). In addition, the applicant should consider the effect of headwinds in the area of operations in which RNP-10 operations are intended to be carried out (see paragraph 15).

(4) Operational Training Programs and Operating Practices and Procedures.

(a) Air carrier operators should submit training syllabi and other appropriate material to the FAA to show that the operational practices and procedures and training items related to RNP-10 operations are incorporated in various training programs where applicable (e.g., initial, upgrade, recurrent). Training for other personnel should be included where appropriate (e.g., dispatchers, maintenance). Practices and procedures in the following areas should be standardized using the guidelines of Appendix 4; flight planning; preflight procedures at the aircraft for each flight; procedures before entry into an RNP-10 route or airspace; inflight, contingency and flightcrew qualification procedures.

(b) Part 91 operators should confirm that they will operate using the practices and procedures identified in Appendix 4.

(5) Operational Manuals and Checklists.

(a) Part 121, 125, 135 Operators. The appropriate manuals and checklists should be revised to include information/guidance on standard operating procedures detailed in Appendix 4. Appropriate manuals should include navigation equipment operating instructions and any procedures established to operate in a specific area of operations (e.g., contingency procedures). Manuals and checklists should be submitted for review as part of the application process.

(b) Part 91 Operators. An airplane Flight Manual and required supplements for the airplane seeking approval should be submitted with the approval package, if one is required for that airplane.

(6) Past Performance. An operating history for the operator should be included in the application. The applicant should address any events or incidents related to Class II Navigation Errors for that operator (e.g., Overseas Navigation Error Reports) which have been rectified by changes in training, procedures, maintenance, or the aircraft/navigation system that are to be used.)

(7) Minimum Equipment List (MEL). Any MEL revisions necessary to address the RNP-10 provisions of this guidance (e.g., if approval is based on Triple-Mix, then the MEL must reflect that three navigation units must be operating).

(8) Maintenance. The operator should submit a maintenance program for approval in accordance with paragraphs 13 and 14 at the time the operator applies for operational approval.

b. Evaluation of Application, Conditions for Removal of Authorization, and Error Reports.

(1) FAA Review and Evaluation of Applications. Once the application has been submitted, the FAA will begin the process of review and evaluation. If the content of the application is insufficient, the FAA will request additional information from the operator. When all the airworthiness and operational requirements of the application are met, the FAA district office will issue the appropriate operations specifications or LOA for approval to operate in RNP-10 airspace, for a specific time period.

(2) Investigation of Navigation Errors. Demonstrated navigation accuracy provides the basis for determining the lateral spacing and separation necessary for traffic operating on a given route. Accordingly, lateral and longitudinal navigation errors are investigated to prevent their reoccurrence. Radar observations of each aircraft's proximity to the centerline and altitude before coming into coverage of short-range navaids at the end of the oceanic route segment are typically noted by Air Traffic Service (ATS) facilities. If an observation indicates that an aircraft was not within an established limit, the reason(s) for the apparent deviation from centerline or altitude may need to be determined and steps taken to prevent a recurrence.

(3) Removal of RNP-10 Authorization. Oceanic Navigation Error Reports (ONER) and Oceanic Altitude Deviation Reports (OADR), for example, are established in FAA Order 7110.82, latest edition and in FAA Order 8700.1, chapter 223. When appropriate, the FAA may consider these reports in determining remedial action. Repeated ONER or OADR occurrences attributed to a specific piece of navigation equipment, may result in withdrawal of operations specifications or rescinding an LOA, for use of that equipment. Information that indicates the potential for repeated errors may require a modification of an operator's training program. Information that attributes multiple errors to a particular pilot crew may necessitate remedial qualifications or airmen certification review.

10. RNP-10 REQUIREMENTS.

a. All aircraft operating in RNP-10 airspace shall have a 95% cross-track error of less than 10 NM. This includes positioning error, flight technical error (FTE), path definition error and display error. All aircraft shall also have a 95% along-track positioning error of less than 10 NM.

NOTE: For RNP-10 approval, navigation positioning error is considered the dominant contributor to cross-track and along-track error. Flight technical error, path definition error, and display error are considered to be insignificant for the purposes of RNP-10 approval. (RNP-10 is intended for oceanic and remote areas where aircraft separation minima, on the order of 50 NM, are applied.)

b. When using the method of Appendix 1 for approval, these error types are included but for the data collection method described in Appendix 6, they are not included since the Appendix 6 method is more conservative. The Appendix 6 method uses radial error instead of cross track and along track error.

(1) Flight Technical Error (FTE). The accuracy with which the aircraft is controlled as measured by the indicated aircraft position, with respect to the indicated command or desired position is the FTE. It does not include blunder errors.

(2) Path Definition. This is the difference between the *defined path* and the *desired path* at a specific point and time.

(3) Display Errors (Display System Error). These errors may include error components contributed by any input, output or signal conversion equipment used by the display as it presents either aircraft

position or guidance commands (e.g., course deviation or command heading) and by any course definition entry device employed. For systems in which charts are incorporated as integral parts of the display, the display system error necessarily includes charting errors to the extent that they actually result in errors in controlling the position of the aircraft relative to a desired path over the ground. To be consistent, in the case of symbolic displays not employing integral charts, any errors in way-point definition, directly attributable to errors in the reference chart used in determining way-point positions, should be included as a component of this error. This type of error is virtually impossible to handle and in general practice, highly accurate, published way-point locations are used to the greatest extent possible in setting up such systems to avoid such errors and reduce workload.

(4) Navigation System Error (NSE). This is the root sum square of the ground station error contribution, the airborne receiver error and the display system contribution.

(5) Total System Error (TSE). This is system use error. $TSE = \sqrt{(NSE)^2 + (FTE)^2}$

(6) Position Estimation. This is the difference between true position and estimated position.

c. Satisfying requirements for an RNP-10 operation in oceanic and remote areas also necessitates that an operation identified in those parts of 14 CFR relevant to the type of operation conducted must also be satisfied, including at least dual carriage of navigation systems of integrity such that the navigation system does not provide misleading information.

11. AIRCRAFT GROUPS (FLEETS OF AIRCRAFT).

a. Definition of Aircraft Group. For aircraft to be considered as members of a group for purposes of RNP-10 approval, they should satisfy the following conditions:

(1) Aircraft should have been manufactured to a nominally identical design and approved by the same Type Certificate (TC), TC amendment, or supplemental TC (STC), as applicable.

NOTE: For derivative aircraft it may be possible to utilize the database from the parent configuration to minimize the amount of additional data required to show compliance. The extent of additional data required will depend on the nature of the changes between the parent aircraft and the derivative aircraft when INS/IRU is used to meet RNP-10 navigation requirements.

(2) The navigation system installed on each aircraft to meet the minimum RNP-10 approval should be manufactured to the manufacturer's same specifications and have the same part numbers.

(3) Where approval is sought for an aircraft group, the data package must contain the following information:

(a) A list of the aircraft group to which the data package applies.

(b) A list of the routes to be flown and the maximum estimated time in navigation from alignment to the time in which the flight will leave Class II Navigation airspace.

(c) The compliance procedures to be used to ensure that all aircraft submitted for approval meet RNP-10 navigation capabilities for the RNP-10 approved time duration.

(d) The engineering data to be used to ensure continued in-service RNP-10 capability for the RNP-10 approved time duration.

NOTE: Aircraft which have INS/IRU's which are of a different manufacturer or part number may be considered part of the group, if it is demonstrated that this navigation equipment provides equivalent navigation performance.

b. Definition of a Nongroup Aircraft. An aircraft for which the operator applies for approval on the characteristics of the unique airframe and navigation system used rather than on a group basis. For nongroup aircraft where airworthiness approval has been based on data collection, the continuing integrity and accuracy of the navigation system shall be demonstrated by the same amount of data collection as is required for group aircraft.

NOTE: Data collected by one or more operators may be used as the basis for approval by another operator and may reduce the number of trials required to obtain approval. Appendix 6 describes a sample data collection procedure and provides sample forms to be used to collect the data.

12. DETERMINING AIRCRAFT ELIGIBILITY.

NOTE : The following groupings are different than the groupings discussed in paragraph 11, above, the groupings below are eligibility groups. These groups were established for the convenience of discussion and do not have a precise definition . The definitions in this order only aid in determining the approval method that may be used to approve specific aircraft and navigation systems. Neither Omega or Doppler systems can be approved for RNP-10.

a. Aircraft Eligibility through RNP Certification (Eligibility Group 1). Group 1 aircraft are those that have obtained formal certification and approval of RNP integration in the aircraft.

(1) RNP compliance is documented in the AFM, and is typically not limited to RNP-10. The AFM will address RNP levels that have been demonstrated and any related provisions applicable to its use (e.g., navaid sensor requirements). Operational approval of Group 1 aircraft will be based upon the performance stated in the AFM.

(2) An airworthiness approval specifically addressing RNP-10 performance may be obtained. Example wording that will be used in AFMs when RNP-10 approvals are granted by Aircraft Certification offices for a change in the INS/IRU certified performance is:

"The XXX navigation system has been demonstrated to meet criteria of FAA Order 8400.12A, as amended, as a primary means of navigation for flights up to XXX hours in duration without updating. The determination of flight duration starts when the system is placed in the navigation mode.

For flights which include airborne updating of navigation position, the operator must address the effect that updating has on position accuracy, and any associated time limits for RNP operations, pertinent to the updating navaid facilities use, and the area, routes, or procedures to be flown.

Demonstration of performance in accordance with provisions of FAA Order 8400.12A, does not constitute approval to conduct RNP operations."

NOTE: The above wording in an AFM is based upon performance approval by Aircraft Certification, it is only one element of the approval process. Aircraft which have had this wording entered into their flight manual will be eligible for approval through issuance of operation specifications or an LOA if all other criteria are met. The XXX hours specified in

the AFM does not include updating. When the operator proposes a credit for updating, the proposal must address the effect the updating has on position accuracy, and any associated time limits for RNP operations pertinent to the updating navaid facilities use, and the area, roots, or procedures to be flown.

b. Aircraft Eligibility Through Prior Navigation System Certification (Eligibility Group 2). Group 2 aircraft are those that can equate their certified level of performance, under previous standards, to the RNP-10 criteria. The standards listed in subparagraphs (1) to (5), below, can be used to qualify an aircraft under Group 2. Other standards may also be used if they are sufficient to ensure that the RNP-10 requirements are met. If other standards are to be used, the FSDO or CMO should consult with AFS-400 to determine the appropriate operational approval and limitations. As new standards are used for the basis of RNP-10, this Order will be revised to reflect the new standards.

(1) Aircraft which Qualify for the /E Suffix as Defined in the Aeronautical Information Manual (AIM). Aircraft equipped with Inertial Navigation Systems (INS), Inertial Reference Units (IRU), Radio Navigation Positioning Updating, and Electronic Map Displays, that qualify for the /E equipment suffix as defined in the AIM, are considered to meet all of the RNP-10 requirements for up to 6.2 hours of flight time. This time starts when the system is placed in the navigation mode. If systems are updated en route, the 6.2 hour RNP-10 time limit must be adjusted after the update to account for the accuracy of the update (see paragraph 12e below for adjustment factors for systems that are updated en route).

NOTE: The consideration to use 6.2 hours of flight time is based on an Inertial System with a 95% Radial Position Error Rate (circular error rate) of 2.0 NM/hr which is statistically equivalent to individual 95% cross-track and 95% along -track position error rates (orthogonal error rates) of 1.6015 NM/hr each, and 95% cross-track and 95% along -track position error limits of 10 NM each (e.g., 10 NM/1.6015 NM/hr = 6.2 hrs).

(2) Aircraft Equipped with INS's or IRU's that have been Approved in Accordance with 14 CFR Part 121, Appendix G. Inertial systems approved in accordance with part 121, appendix G, are considered to meet RNP-10 requirements for up to 6.2 hours of flight time. This time starts when the system is placed in the navigation mode. If systems are updated en route, the 6.2 hours RNP-10 time limit must be adjusted to account for the accuracy of the update. INS accuracy, reliability, training, and maintenance issues that are required by section 121.355, appendix G, are considered to be applicable to an RNP-10 authorization, including any associated Class II Navigation procedures. Except as authorized by the Administrator in accordance with section 121.351(c) at least dual equipage of eligible INS systems is required.

(3) Aircraft Equipped with INS's or IRU's Approved for Australian RNAV Operations. Aircraft equipped with dual INS's or IRU's approved for MNPS operations or RNAV operations in Australia can be considered to meet RNP-10 requirements for up to 6.2 hours after the system is placed in the navigation mode.

NOTE: Paragraph 12d provides information on acceptable procedures for operators that desire to increase the 6.2 hours of flight time specified.

(4) Aircraft Equipped with Global Positioning Systems (GPS) Approved to Primary Means of Navigation Standards. Aircraft approved to use GPS as a primary means of navigation for oceanic and remote operations in accordance with the appropriate FAA documents, or equivalent, are considered to meet the RNP-10 requirements without time limitations. The AFM(s) should indicate if a particular GPS installation meets the appropriate FAA documents requirements. As specified in the appropriate FAA documents, at least dual GPS equipment is required, and an approved dispatch fault detection and exclusion (FDE) availability prediction program must be used. The maximum allowable time for which

FDE capability is projected to be unavailable is 34 minutes. The maximum outage time should be included as a condition of the RNP-10 approval. (See FAA Handbook Bulletin [HBB] for Air Transportation [HBAT], number HBAT 95-09, Guidelines for Operational Approval of Global Positioning System [GPS] to Provide the Primary Means of Class II Navigation in Oceanic and Remote Areas of Operation)

NOTE: If predictions indicate that the maximum FDE outage for the intended RNP-10 operation cannot be met, then the operation must be rescheduled when FDE is available, or RNP-10 must be predicated on an alternate means of navigation.

(5) Multisensor Systems Integrating GPS (with GPS Integrity Provided by Receiver Autonomous Integrity Monitoring (RAIM)). Multisensor systems integrating GPS with RAIM or FDE that are approved using the guidance of AC 20-130A, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors, or equivalent, can be considered to meet RNP-10 requirements without time limitations. In this case, the INS or IRU must be approved in accordance with part 121, appendix G.

c. Aircraft Eligibility Through Data Collection (Eligibility Group 3). A data collection program should address appropriate navigation accuracy requirements for RNP-10. The data collection must ensure that the applicant demonstrates to the FAA that the aircraft and navigation system provides the flightcrew with navigation situational awareness relative to the intended RNP-10 route. The data collection must also ensure that a clear understanding of the status of the navigation system is provided, and that failure indications and procedures are consistent with maintaining the required navigation performance. Two types of data collection are described in this order, a sequential and a periodic data collection method.

(1) The sequential method is a data collection program meeting provisions of Appendix 1. This method allows the operator to collect data and plot it against the Pass-Fail graphs to determine if the operator's system will meet RNP-10 requirements for the length of time needed by the operator.

(2) The periodic method of data collection employs the use of a hand-held GPS receiver as a base line for collected INS data, which is described in Appendix 6, (Periodic Method). The collected data is then analyzed as described in Appendix 6 to determine if the system is capable of maintaining RNP-10 for the length of flight desired by the operator.

d. Obtaining Approval for an Extended Time Limit for INS or IRU Systems. The baseline RNP-10 time limit for INS and IRU systems after the system is placed in the navigation mode is 6.2 hours, as detailed in paragraphs 12b(1)(2) and (3). This time limit may be extended by one of the following methods:

(1) An extended time limit may be established when RNP is integrated into the aircraft navigation system through a formal certification process (as described in paragraph 12a).

(2) When an INS or IRU has been approved using an existing approval standard (as detailed in paragraphs 12b(1)(2) and (3)), an extended time limit may be established by an applicant presenting justifying data to the appropriate Aircraft Certification Office. Group approvals will be granted by aircraft certification with appropriate restrictions if the collected data indicates that approval is merited.

(3) An applicant may establish an extended time limit by showing that the carriage of multiple navigation sensors, that mix or average navigation position error, justifies such an extension (e.g., triple mixed INS's). If the applicant uses a time limit based on mixing, then the availability of the mixing capability is required for 14 CFR parts 121, 125, and 135 dispatch or for part 91 takeoff for flight on RNP-10 routes. If the mixing or averaging function is not

available at dispatch, then the applicant must use a time limit that does not depend on mixing. The extended time limit must be validated by a data collection program and analysis as specified in paragraph 12d(4).

(4) When an INS or IRU has been approved using an existing approval standard, operators can establish an extended time limit by conducting a data collection program in accordance with the guidance provided in Appendix 1 or Appendix 6.

e. Effect of En route Updates. Operators may extend their RNP-10 navigation capability time by updating. Approvals for various updating procedures are based upon the baseline for which they have been approved minus the time factors shown below:

(1) Automatic updating using DME/DME = Baseline minus 0.3 hours (e.g., an aircraft that has been approved for 6.2 hours can gain 5.9 hours following an automatic DME/DME update).

(2) Automatic updating using DME/VOR = Baseline minus 0.5 hours.

(3) Manual updating using a method similar to that contained in Appendix 7 or approved by AFS-400 = Baseline minus one hour.

f. Conditions under which Automatic Radio Position Updating may be considered as Acceptable for Flight in Airspace where RNP-10 is Required. Automatic updating is considered to be any updating procedure that does not require crews to manually insert coordinates. Automatic updating may be considered acceptable for operations in airspace where RNP-10 is applied provided that:

(1) Procedures for automatic updating are included in an operator's training program.

(2) Crews are knowledgeable of the updating procedures and of the effect of the update on the navigation solution.

(3) An acceptable procedure for automatic updating may be used as the basis for an RNP-10 approval for an extended time as indicated by data presented to the POI or ASI. This data must present a clear indication of the accuracy of the update and the effect of the update on the navigation capabilities for the remainder of the flight.

g. Conditions under which Manual Radio Position Updating may be Considered as Acceptable for Flight in Airspace where RNP-10 is Required. If manual updating is not specifically approved, manual position updates are not permitted in RNP-10 operations. Manual radio updating may be considered acceptable for operations in airspace where RNP-10 is applied provided that:

(1) Procedures for manual updating are reviewed by AFS-400 on a case-by-case basis. An acceptable procedure for manual updating is described in Appendix 7 and may be used as the basis for an RNP-10 approval for an extended time when supported by acceptable data.

(2) The operator shows that updating procedures and training contain measures for cross checking to prevent blunder errors and that the crew qualification curriculum is found to provide effective pilot training.

(3) The operator provides data that establishes the accuracy with which the aircraft navigation system can be updated using manual procedures and representative navigation aids. Data should be

provided that shows the update accuracy achieved in in-service operations. This factor must be considered when establishing the RNP-10 time limit for INS's or IRU's. (See paragraph 12e.)

13. MEL. If RNP-10 operational approval is granted on the basis of a specific operational procedure (such as credit for Triple-Mix), operators should make MEL adjustments specifying the required dispatch conditions through their CHDO.

14. CONTINUING AIRWORTHINESS (MAINTENANCE REQUIREMENTS). Aircraft in Group 1, Group 2, and Group 3 should have an established maintenance program for the individual navigation systems. For others installing navigation systems, the operator will submit those changes appropriate to their existing maintenance manual for review and acceptability.

15. OPERATIONAL REQUIREMENTS.

a. Navigational Performance. All aircraft shall meet a track keeping accuracy equal to or better than ± 10 NM for 95% of the flight time in RNP-10 airspace. All aircraft shall meet along - track positioning accuracy of ± 10 NM for 95% of the flight time in RNP-10 airspace.

b. Navigation Equipage. All aircraft RNP-10 operation in oceanic and remote areas except as authorized by the Administrator in accordance with section 121.351(c), shall have at least dual carriage of navigation systems of integrity such that the navigation system does not provide misleading information.

c. Flight Plan Designation. Operators should use the appropriate FAA or ICAO flight plan designation specified for the RNP-10 route flown. The letter "R" should be placed in Block 10 of the ICAO flight plan to indicate that the pilot has reviewed the planned route of flight to determine RNP-10 requirements and the aircraft and operator have been approved by the FAA to operate in areas or on routes where
RNP-10 is a requirement for operation.

NOTE: The letter that indicates RNP approval has not yet been established for FAA flight plans.

d. Availability of NAVAIDS. At dispatch or during flight planning, the operator should ensure that adequate navigation aids are available en route to enable the aircraft to navigate to RNP-10.

e. Route Evaluation for RNP-10 Time Limits for Aircraft Equipped with only INS's or IRU's. As detailed in paragraph 12e, Effects of En route Updates, an RNP-10 Time Limit must be established for aircraft equipped only with INS's or IRU's to meet the RNP-10 accuracy requirement. When planning operations in areas where RNP-10 is applied, the operator must evaluate its intended route(s) of flight in relation to the RNP-10 time limit. In making this evaluation, the operator must consider the effect of headwinds. The operator may choose to make this evaluation on a one time basis (75% probability wind components) or on a per flight basis.

(1) Route Evaluation. The operator must establish its capability to satisfy the RNP-10 time limit established for dispatch or departure into RNP-10 airspace.

(2) Start Point for Calculation. The calculation should start at the point where the system is placed in the navigation mode or the point where it is expected to be updated.

(3) Stop Point for Calculation. The stop point may be one of the following:

(a) the point at which the aircraft will begin to navigate by reference to ICAO Standard Navaids (VOR, DME, NDB) and/or comes under radar surveillance from ATC; or

(b) the point at which the navigation system is expected to be updated.

(4) Sources of Wind Component Data. The headwind component to be considered for the route may be obtained from any source found acceptable to the FAA. Acceptable sources for wind data include: National Weather Service, Bracknell, industry sources such as Boeing Winds on World Air Routes, and historical airline data supplied by the operator.

(5) One Time Calculation Based on 75% Probability Wind Components. Certain sources of wind data establish the probability of experiencing a given wind component on routes between city pairs on an annual basis. If an operator chooses to make a one time calculation of RNP-10 time limit compliance, it may use the annual 75% probability level to calculate the effect of headwinds (this level has been found to be a reasonable estimation of wind components).

(6) Calculation of Time Limit For Each Specific Fight. The operator may choose to evaluate each individual flight using flight planned winds to determine if the aircraft will comply with the specified time limit. If it is determined that the time limit will be exceeded, then the aircraft must fly an alternate route or delay the flight until the time limit can be met. This evaluation should be considered a flight planning or dispatch task.

16. DISCUSSION OF CERTIFICATION ACTIONS RELATED TO RNP-10.

a. The operator may elect to certify the aircraft navigation performance to a new standard to take advantage of the aircraft capability. The aircraft may obtain credit for improved performance through operational data collection, in which case certification is not necessary. The following paragraphs provide guidelines for different types of navigation systems. The applicant must propose an acceptable means of compliance for any systems not identified below.

(1) Aircraft Incorporating INS. For aircraft with INS certified under part 121, appendix G, additional certification is only necessary for operators who choose to certify INS accuracy to better than 2 NM per hour radial error.

(a) The certification of INS performance must address all issues associated with maintaining the required accuracy including, accuracy and reliability, acceptance test procedures, maintenance procedures, and training programs.

(b) The applicant should identify the standard against which INS performance is to be demonstrated. This standard may be a regulatory (i.e., appendix G), industry, or applicant unique specification. A statement should be added to the AFM identifying the accuracy standard used for certification. (See paragraph 12a(2).)

(2) Aircraft Incorporating GPS. AC 20-138 provides an acceptable means of compliance for aircraft that use GPS, but do not integrate the GPS with other sensors. AC 20-130A, describes an acceptable means of compliance for multi-sensor navigation systems that incorporate GPS. Aircraft which intend to use GPS as the only navigation system in RNP-10 airspace (e.g., no IRS or INS), must also comply with the requirements of the appropriate FAA documents, except for specific GPS requirements described in this Order.

b. The equipment configuration used to demonstrate the required accuracy must be identical to the configuration which is specified in the MEL.

c. The equipment configuration used to demonstrate the required accuracy must be supportable in RNP-10 oceanic and remote airspace. For example, the statistical benefit of estimating position using INS position data filtered with DME data, will not be considered.

Thomas E. Stuckey
Acting Director, Flight Standards Service

APPENDIX 1. AIRCRAFT ELIGIBILITY THROUGH DATA COLLECTION

1. GENERAL.

a. This appendix offers broad guidance to principal operation inspectors (POI) in the use of a statistical procedure to determine whether aircraft should be approved for flight in RNP-10 airspace. Inspectors are to consider each application on its own merit, and should weigh such factors as the operator's experience, crew training procedures, the airspace in which error data are accumulated (e.g., NOPAC, CEPAC, NAS, MNPS), and the age of the data. Inspectors may request a review of the data by FAA navigation specialists or by AFS-400.

b. RNP-10 approvals will be issued for specific combinations of aircraft and navigation system. If the navigation system which is a candidate for RNP-10 approval is an INS, IRS, or any other system whose accuracy decreases with increasing flight time, the approval must be limited to the number of hours during which the aircraft can be expected to satisfy both the lateral ("cross-track") and longitudinal ("along-track") accuracy criteria of RNP-10.

c. This appendix describes statistical tests that use data gathered from repeated flights. Invoking standard statistical terminology, the appendix refers to a flight trial. This means for example an aircraft with three INS's could provide three data points (trials per flight). In each trial the operator measures two errors:

(1) the longitudinal position-determination error of the candidate navigation system; and

(2) the lateral deviation of the candidate aircraft from its planned route center line.

The longitudinal position-determination error measured in the i^{th} trial is called a_i; the lateral deviation measured in the i^{th} trial is called c_i. In order for the statistical test to be valid, the data gathered in each trial must be independent of those gathered in any other trial. In other words, the outcome of each trial must not influence the outcome of any subsequent trial. Data will typically be gathered after an aircraft has flown for at least as long as the time for which operational approval is being requested, while being guided solely by the navigation system which is a candidate for RNP-10 approval.

d. An operator requesting RNP-10 approval for a candidate aircraft and navigation system must inform the FAA of the flights during which it plans to collect error data. The operator should collect data on every eligible flight until the statistical procedure described in this appendix indicates that the data collection should cease. The operator must use all valid data, and, in particular, may not ignore data that show large errors while submitting only those that show small errors.

2. DATA COLLECTION GUIDELINES.

a. Operators using the methods described in this appendix are to collect position estimates and use those estimates to compute the lateral and longitudinal errors of their aircraft. If a combination of aircraft and navigation system is a candidate for RNP-10 approval for a stated number of hours *h*, the data must be collected at least *h* hours after that navigation system was last updated or initialized. Furthermore, the data must be collected after the aircraft has been guided solely by that navigation system for a period long enough to eliminate the effects of prior guidance by any other navigation system that the aircraft may have used during its flight.

b. In order to determine the lateral and longitudinal error data, the operator must simultaneously obtain position estimates from:

(1) the navigation system which is a candidate for RNP-10 approval (the candidate system); and

(2) a reference system, which must be highly accurate in the area where the position is estimated. (The estimate from the reference system is taken to represent the aircraft's actual position.)

The candidate-system position and the reference-system position must be measured simultaneously, at a time when the aircraft has been flying along a straight segment of its planned route for several minutes, and is expected to continue flying along that segment for several more minutes. The operator must ensure that the aircraft's actual position at the time of the measurement is due to guidance derived solely from the candidate system. In particular, the operator must ensure that no other navigation system (especially the reference system) contributed, to any significant extent, to the aircraft's position at the time of the measurement.

c. The operator is responsible for establishing that reference-system positions are accurate. The operator may wish to consider the following in selecting reference systems:

(1) DME/DME positions taken within 200 NM of both DME stations, derived automatically and displayed on systems such as Flight Management Computers.

(2) GPS derived positions.

(3) VOR/DME positions taken within 25 NM of the navigation aid.

NOTE: Operators considering the use of these systems are reminded that many of them are installed so that their outputs are automatically used to guide the aircraft. If any system other than the candidate system has significant influence on the aircraft's position at the time when position estimates are obtained, the test of the candidate system will not be valid.

d. The positions simultaneously reported by the candidate system and the reference system must both be expressed (or re-expressed) in terms of the same coordinate system. The longitudinal error a_i is the distance between the position reported by the reference system and the position reported by the candidate system, measured along a line parallel to the planned route of flight. (Thus, if the two reported positions are connected by a vector, and the vector is resolved into a component parallel to the route and a component perpendicular to the route, a_i is the magnitude of the component parallel to the route). The lateral deviation c_i is the distance between the planned route of flight and the position reported by the reference system (Note that the position reported by the candidate system has no role in determining the value of c_i.). The distances a_i and c_i must be absolute distances expressed in NM, i.e., expressed as non-negative numbers. In particular, longitudinal errors in opposite directions do not offset each other; nor do lateral deviations to the left and right offset each other.

e. Suppose for example, that an operator wishes to obtain RNP-10 approval of an airplane equipped with an INS, and that the RNP-10 time limit being sought for the INS is 6 hours. Suppose also, that the airplane can very accurately determine its position when it is in airspace with multiple DME coverage, and that it usually enters a large block of such airspace 5½ hours after the last use of another navigation system or signal to adjust its INS output. On each occasion when:

(1) the airplane is flying in an area of multiple DME coverage;

(2) at least 6 hours have passed since the last adjustment of INS output; and

(3) the airplane has been flying straight for several minutes, and is expected to continue flying straight for several more minutes; the crew records: (1) the time; (2) the desired track (or just the "from" and "to" waypoints); (3) the position reported by the INS; and (4) the position reported by the multiple-DME system. The operator later computes the longitudinal error a_i and the lateral deviation c_i.

f. The following is a non-technical summary of the steps used in collecting, plotting, and analyzing data collected for the purpose of using the pass-fail graphs in this appendix. The data collected indicates the difference between the aircraft's navigation system and a highly accurate reference system. The position determined from the reference system is the aircraft's actual position. The point at which this data should be taken is when first leaving Class II Navigation at the designation end of the flight.

(1) Operator collects the following independent data on each eligible flight:

(a) on the desired flightpath, the last waypoint (last waypoint passed) and the to waypoint (these points should be taken from the flight plan),

(b) the reference system (e.g., DME/DME) computed aircraft position

(c) aircraft guidance system (e.g., INS) computed aircraft position for each system
NOTE: (b) and (c) measurements should be taken simultaneously.

(2) The data must be taken after the guidance system (candidate navigation system) has been operating without any external update for a time at least as long as the time limit being requested.

(3) The data gathered in subparagraph (1), above, is now used to calculate:

(a) cross track error (lateral deviation c_i)

(b) along track error (longitudinal deviation a_i)
NOTE: a_i in (b), above, is considered to represent along track error.

(4) Cross Track Error (c_i). Calculate the perpendicular distance from the reference system computed aircraft position to the desired flightpath (the desired flightpath is a great circle line between the last waypoint and the to waypoint).

(5) Along Track Error (a_i). Calculate the distance between the reference system computed aircraft position and the guidance system (INS, etc.) computed aircraft position along a line parallel to the desired flightpath.

(6) Cross Track Pass/Fail. Following the first flight, errors are summed (e.g., if the error was 2 NM on the first flight and 3 NM on the second flight then the cumulative error would equal 5. The cumulative error is the value of the ordinate (y coordinate in a Cartesian coordinate system) and the number of trials is the value of the abscissa (x coordinate in a Cartesian coordinate system). The intersection of these two is then plotted on figure 1. The cross track RNP-10 requirements are passed when the plots of the cumulative errors fall below the lower pass line or fail if they go above the upper fail line.

(7) Along Track Pass/Fail. Following each flight, the errors are squared and following the first flight, the errors squared are summed (e.g., if the error was 2 NM on the first flight and 3 NM on the second flight then the cumulative squared errors would equal 4 + 9 = 13. The cumulative error squared is the value of the ordinate (y coordinate in a Cartesian coordinate system) and the number of trials is the value of the abscissa (x coordinate in a Cartesian coordinate system). The intersection of these two values is then plotted on

figure 2. The along track RNP-10 requirements are passed when the plots of the cumulative errors squared fall below the lower pass line or fail if they pass above the upper fail line.

g. Operators planning to use their aircraft in a particular route system should gather error data from flights through that system (e.g., NOPAC, CEPAC). If operations are planned for an area other than the one in which data are collected, the operator should show that navigational performance will not be degraded there.

h. The operator should develop a standard form on which to document each flight. It should include:

(1) Date
(2) Departure airport
(3) Destination airport
(4) Aircraft type, series and registration number
(5) Make and model of the candidate navigation system
(6) Type of reference system used (e.g., VOR/DME, DME/DME)
(7) Time at which the candidate system is placed in navigation mode
(8) Times (if any) at which the candidate system is updated while en route
(9) Time at which positions are recorded from the candidate system and the reference system
(10) Reference system position coordinates
(11) Candidate system position coordinates
(12) Desired track, or waypoints passed immediately before and after the recorded positions

After the flight the operator computes the lateral deviation c_i and the longitudinal error a_i, as indicated above.

3. STATISTICAL PROCEDURES.

a. Background. Sequential sampling procedures are used to determine whether a candidate aircraft and navigation system should receive RNP-10 approval. After each trial the operator recomputes certain statistics and compares them to numbers indicated below. The comparison will infer one of three possible results:

(1) the candidate aircraft and navigation system satisfy the RNP-10 performance requirements, and the statistical test is terminated; or

(2) the candidate aircraft and navigation system do not satisfy the RNP-10 performance requirements, and the statistical test is terminated; or

(3) the operator needs to perform another trial (i.e., gather more data) and continue the statistical test, as it cannot yet reach a decision with the required level of confidence.

b. A sequential sampling procedure typically requires fewer trials than does a statistical test that has a fixed number of trials and has the same probability of making the correct decision. In general, the better an aircraft navigates, the fewer trials it will need to pass the test, i.e., to demonstrate RNP-10 compliance. However, for the FAA to have sufficiently high confidence in the test results, even an aircraft that navigates perfectly will need to perform at least 13 trials in order to demonstrate that it meets the RNP-10 lateral containment criterion, and at least 19 trials to demonstrate that it meets the RNP-10 longitudinal accuracy criterion. An aircraft that navigates poorly will need relatively few trials before failing the test. The test has been designed so that the average number of trials needed for it to reach a decision is approximately 100.

c. Test of Lateral Conformance. To establish whether or not the navigation system meets the RNP-10 lateral containment criterion, the operator may use the mathematical process described in this paragraph, or use the graph shown in figure 1 and described in paragraph 3e. After conducting at least 13 trials, the operator should add together all of the lateral deviations obtained up to that point. Suppose, in particular, that n trials have been conducted. If the sum of lateral deviations does not exceed $2.968n - 37.853$, the candidate aircraft and navigation system have demonstrated compliance with the RNP-10 lateral containment criterion, and the operator should stop computing lateral deviation data. If the sum of the lateral deviations equals or exceeds $2.968n + 37.853$, the candidate aircraft and navigation system have demonstrated that they do not meet the RNP-10 lateral containment criterion, and the operator should stop computing lateral deviation data. If the sum of the lateral deviations is between $2.968n - 37.853$ and $2.968n + 37.853$, the test cannot yet yield a decision. The operator must perform another trial to obtain an additional lateral deviation. This new lateral deviation is added to the sum obtained previously, and the new sum is then compared to $2.968(n+1) - 37.853$ and $2.968(n+1) + 37.853$.

d. In other words, let $S_{c,n} = c_1 + c_2 + ... + c_n$ be the sum of (the absolute values of) the lateral deviations obtained in the first n trials. If $S_{c,n} \leq 2.968n - 37.853$, the aircraft and its navigation system pass the lateral conformance test. If $S_{c,n} \geq 2.968n + 37.853$, the aircraft and its navigation system fail the lateral conformance test. If $2.968n - 37.853 < S_{c,n} < 2.968n + 37.853$, the operator must:

(1) perform another trial to obtain c_{n+1};

(2) compute $S_{c,n+1} = c_1 + c_2 + ... + c_n + c_{n+1}$ $(= S_{c,n} + c_{n+1})$;

(3) compare $S_{c,n+1}$ to $2.968(n+1) - 37.853$ and to $2.968(n+1) + 37.853$; and

(4) determine whether the candidate aircraft and navigation system pass the test or fail the test, or whether an $(n + 2)^{th}$ trial is needed.

e. Figure 1 illustrates these rules for the lateral conformance test. The operator may wish to plot points on figure 1 as lateral deviation data are collected. The abscissa (horizontal component) of each plotted point is n, the number of trials completed; and the ordinate (vertical component) of each point is $S_{c,n}$, the sum of the (absolute values of the) lateral deviations observed in the n trials. The test ends as soon as a point falls into the lower right region or the upper left region of the graph. If a point is plotted in the lower right region, the candidate aircraft and navigation system have shown that they satisfy the RNP-10 lateral containment criterion. If a point is plotted in the upper left region the candidate aircraft and navigation system have demonstrated that they do not meet the criterion. Whenever a point is plotted in the middle region, the operator needs to accumulate more data.

f. In the event that the tests of $S_{c,n}$ do not yield a decision on the aircraft's lateral performance after 200 trials, the operator should perform the following computations:

(1) Compute the quantity $D_1 = c_1^2 + c_2^2 + \ldots + c_{200}^2$

(2) Compute the quantity $D_2 = \frac{S_{c,200}^2}{200} = \frac{(c_1 + c_2 + \ldots + c_{200})^2}{200}$

1

(3) Compute the quantity $D_c^2 = \frac{D_1 - D_2}{200}$

If D_c^2 does not exceed 18.649, the aircraft and navigation system satisfy the RNP-10 lateral containment criterion. If D_c^2 does exceed 18.649, the aircraft and navigation system do not meet the criterion, and do not qualify for RNP-10 approval.

g. Test of Longitudinal Accuracy. To establish whether or not the navigation system can meet the RNP-10 longitudinal accuracy criterion the operator may use the mathematical process described in paragraphs 3h and 3i, or use the graph provided in figure 2, as described in paragraph 3j.

h. After conducting at least 19 trials, the operator should add together the squares of all the longitudinal errors obtained up to that point. Suppose, for example, that *n* trials have been conducted. If the sum of the squares of the longitudinal errors does not exceed 22.018*n* - 397.667, the aircraft and navigation system have demonstrated compliance with the RNP-10 longitudinal accuracy requirement, and the operator should stop computing longitudinal error data. If the sum of the squares of the longitudinal errors exceeds 22.018*n* + 397.667, the aircraft and navigation system have demonstrated that they do not meet the RNP-10 longitudinal accuracy requirement, and the operator should stop computing longitudinal error data. If the sum of the squares of the longitudinal errors is between 22.018*n* - 397.667 and 22.018*n* + 397.667, the test cannot yield a decision. The operator must perform another trial to obtain an additional longitudinal error. The square of this new longitudinal error is added to the sum obtained previously, and the new sum is then compared to 22.018(*n*+1) - 397.667 and to 22.018(*n*+1) + 397.667.

i. In other words, let $S_{a,n} = a_1^2 + a_2^2 + \ldots + a_n^2$ be the sum of the squares of the longitudinal errors obtained in the first *n* trials. If $S_{a,n} \leq 22.018n - 397.667$, the aircraft and its navigation system pass the longitudinal accuracy test. If $S_{a,n} \geq 22.018n + 397.667$, the aircraft and its navigation system fail the longitudinal accuracy test. If $22.018n - 397.667 < S_{a,n} < 22.018n + 397.667$, the operator must:

(1) perform another trial to obtain another longitudinal error a_{n+1};

(2) compute $S_{a,n+1} = a_1^2 + a_2^2 + \ldots + a_n^2 + a_{n+1}^2$ $(= S_{a,n} + a_{n+1}^2)$;

(3) compare $S_{a,n+1}$ to 22.018(*n*+1) - 397.667 and to 22.018(*n*+1) + 397.667; and

(4) determine whether the candidate aircraft and navigation system pass the test or fail the test, or whether an $(n + 2)^{th}$ trial is needed.

j. Figure 2 illustrates the rules for the sequential test of longitudinal accuracy. The operator may wish to plot points on figure 2 as longitudinal error data are collected. The abscissa (horizontal component) of a plotted point is *n*, the number of trials completed; and the ordinate (vertical component) of a point is $S_{a,n}$, the sum of the squares of the longitudinal errors observed in the *n* trials. The test ends as soon as a point falls into the lower right region or the upper left region of the graph. If a point is plotted in the lower right region, the candidate aircraft and navigation system have shown that they satisfy the RNP-10 longitudinal accuracy criterion. If a point is plotted in the upper left region, the aircraft and navigation system have demonstrated that they do not meet that criterion. Whenever a point is plotted in the middle region, the operator needs to accumulate more data.

k. In the event that the sequential sampling procedure described above does not yield a decision on the aircraft's longitudinal performance after 200 trials, the operator should perform the following computations:

(1) Compute the quantity $D_3 = \frac{(a_1 + a_2 + \ldots + a_{200})^2}{200}$

(2) Compute the quantity $D_a^2 = \frac{S_{a,200} - D_3}{200}$

If D_a^2 does not exceed 21.784, the aircraft and navigation system satisfy the RNP-10 longitudinal accuracy criterion. If D_a^2 does exceed 21.784, the aircraft and navigation system do not meet the criterion, and do not qualify for RNP-10 approval.

Figure 1: Acceptance, Rejection, and Continuation Regions for Sequential Test of Lateral Conformance

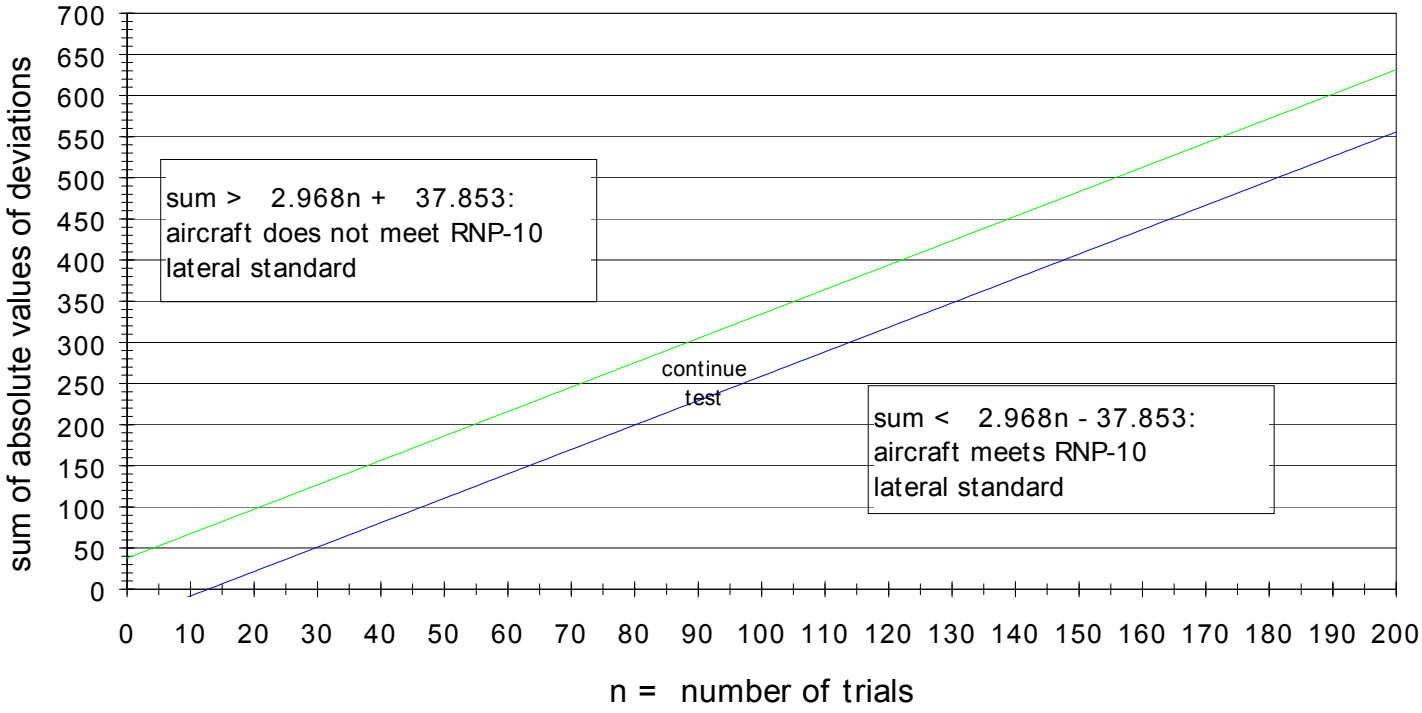
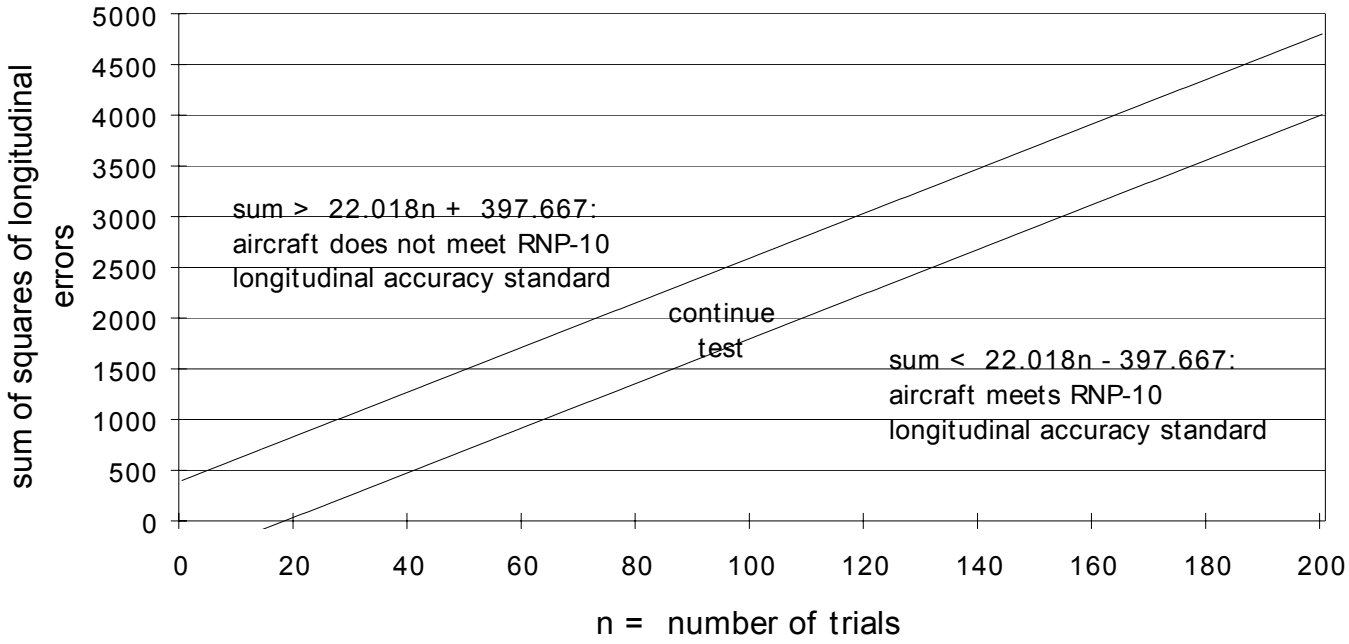


Figure 2: Acceptance, Rejection and Continuation
Regions for Sequential Test of Longitudinal Accuracy



APPENDIX 2. CERTIFICATION OF IRU PERFORMANCE

1. GUIDELINES AND ASSUMPTIONS. IRU's that meet the current requirements of part 121, appendix G, meet all of the RNP-10 requirements for up to 6.2 hours of flight time without radio position updating. IRU accuracy, reliability, training, and maintenance issues that are required by appendix G, are part of the aircraft certification. However, IRU manufacturers believe that the actual performance of some types of IRU's exceeds the current appendix G requirements. A methodology for analyzing IRU performance, combined with requirements to update IRU manufacturer's Specification Control Drawings (SCD), Acceptance Test Procedures (ATP), and airline IRU maintenance /removal criteria is described in the following paragraph.

2. CERTIFICATION GUIDELINES.

a. IRU Accuracy and Reliability. IRU accuracy and reliability must be analyzed in conjunction with the flight management system interface. An analysis performed on a specific manufacturer's aircraft model is not necessarily applicable to other aircraft operating the same equipment. However, other aircraft may be analyzed using the same or equivalent methodology as proposed herein.

(1) The Radial Navigation Error Distribution for IRU's is Modeled by a Rayleigh Distribution. The 95% statistic of radial position error will be used when demonstrating compliance. It is assumed that cross-track and along-track errors are Gaussian, independent, and have equal variances.

(2) The Radial Position Error will be Evaluated for the Range of the Independent Time Variable (time in navigation), as certified for the IRU navigation maximum time (e.g., 18 hours).

(3) Time-Dependent Position Error Data will be Presented. Other non-inertial error sources will not be considered as part of the IRU certification (i.e., flight technical error). Therefore, the maximum time duration of flight operations in RNP-10 airspace will be evaluated and determined as part of the operational approval.

(4) The Assessment of Navigation Performance may Employ System Analysis, IRU Error Modeling (Covariance Analysis), and System Simulation. Analytical findings may be validated with empirical data from laboratory testing and aircraft flight testing, as applicable.

b. When credit is required for IRU performance that is superior to the original certification, the existing IRU specification control drawings for the IRU Type Designs should be revised to account for the new tighter tolerance system error budgets. If it has been determined that all IRU's for a given part number meet the minimum requirements of the new performance standard, then the IRU part number may remain the same. When only some of the IRU's for a given part number meet the minimum requirements of the new performance standard, then screening is required and part number updates will be required to identify the IRU's which are compliant to the new performance standard.

c. The AFM or AFM Supplement (AFMS) must be modified to reflect the certification of IRU's to tighter accuracy requirements, consistent with AC 25-4, Inertial Navigation System (INS), paragraph 5b(4). The AFM should provide sufficient time-dependent information so that the maximum time in RNP-10 airspace can be assessed as part of the operational approval.

d. In addition, production and field acceptance test procedures will require an update by the supplier, to ensure that the installed IRU meets the tighter accuracy tolerance required.

e. Operator maintenance procedures will require updating to ensure appropriate monitoring of IRU performance to the new requirements contained in this Order, and replacement of IRU's on aircraft that do not meet the navigation performance of this new criteria.

f. Procedures for flight operations should be identified and applied to ensure IRU alignment before extended range flights and time-in-navigation for the intended time duration of flight in RNP-10 airspace.

APPENDIX 3. DOCUMENTATION REQUIRED TO COMPLETE THE APPROVAL PROCESS

FIGURE 1. SAMPLE LETTER OF REQUEST BY AN AIR CARRIER TO OBTAIN RNP-10 OPERATIONAL APPROVAL

SUBJECT: Request for Required Navigation Performance (RNP) - 10 Approval

TO: Appropriate POI

[*Insert Airline Name*] request that Operations Specifications approval be issued to conduct en route operations on RNP [*insert number*] of [*insert number*] hours between updates on designated routes.

The following [*Insert Airline Name*] aircraft meet the requirements and capabilities as defined/specified in Federal Aviation Administration Order [*insert the number of this Order*], dated [*insert the date of this Order*] for a RNP-10 qualification.

AIRCRAFT TYPE/SERIES	RNP-10 TIME LIMIT *	NAVIGATION EQUIPMENT	COMMUNICATIONS EQUIPMENT
B-747-400 Name and		List Nav Equip by Name and Type/Manuf/Model	List Com Equip by Type/Manuf/Model
B-737-500 Name and		List Nav Equip by Name and Type/Manuf/Model	List Com Equip by Type/Manuf/Model
MD-11 Name and		List Nav Equip by Name and Type/Manuf/Model	List Com Equip by Type/Manuf/Model

Note: The above listed aircraft are samples only.

Training of flightcrews have been accomplished in accordance with applicable FAA regulations and guidance material.

* If unlimited time is requested, state: "Unl."

Sincerely,

[*insert typed name and signature*]

[*insert title*]

APPENDIX 3. DOCUMENTATION REQUIRED TO COMPLETE THE APPROVAL PROCESS

FIGURE 2. SAMPLE LETTER OF REQUEST BY A GENERAL AVIATION OPERATOR TO OBTAIN RNP-10 OPERATIONAL APPROVAL

SUBJECT: Request for a Letter of Authorization (LOA) to conduct Required Navigation Performance (RNP)

TO: Appropriate Flight Standards District Office (FSDO)

Operators must submit requests by letter with a separate page containing the "Format for an LOA to Operate at RNP-10" as shown on the following page.

LOA's

Aviation safety inspectors (ASI) can administratively issue an LOA to any general aviation operator that has an aircraft-navigation system meeting the requirements of this Order. The procedure for the issuance of the LOA is identical to the procedure contained in FAA Order 8700.1, chapter 222, with the exception that the format for the LOA has been modified to meet the specific requirements of an RNP approval. The format to be used is contained on the following page and may be copied or retyped at the convenience of the operator. If the LOA is retyped, inspectors will ensure that every item appearing in the sample, is included in the operator's version.

APPENDIX 3. DOCUMENTATION REQUIRED TO COMPLETE THE APPROVAL PROCESS

FORMAT FOR AN LOA TO OPERATE AT RNP-10

This letter constitutes approval for the named aircraft to operate or to conduct oceanic/remote area flight on routes specified as RNP-10 routes at the level indicated by the authorized operator or crew listed under the conditions and limitations below.

Aircraft make and model _____ N-Number _____
Aircraft serial number _____ Aircraft color _____

NAVIGATION EQUIPMENT

TYPE/MANUFACTURER/MODEL	PART NUMBER	DATE INSTALLED	RNP-10 TIME LIMIT

COMMUNICATION EQUIPMENT

TYPE/MANUFACTURER/MODEL	PART NUMBER	DATE INSTALLED

Aircraft base of operations (city, state, zip) _____
Name of aircraft owner/operator _____
Crew training conducted by _____
Print name of person responsible for crew operations or agent for service (must be a U.S. citizen)

_____
Signature of person responsible for crew operations or agent for service

_____
Street address (cannot be a Post Office box)

_____
City, state, and zip code _____

FOR FAA USE ONLY (To be completed by issuing office)

This approval is for: RNP-10 under the conditions typed on the back of this authorization.
Authorization Number _____
Aircraft limitations (if applicable) _____
Program Tracking and Reporting Subsystem (PTRS) tracking number _____
Date of Issuance _____ Expiration Date _____

This authorization is subject to the conditions that all operations conducted on an oceanic RNP route are in accordance with the flight rules contained in International Civil Aviation Organization (ICAO), Annex 2, and that all operations outside of the United States comply with section 91.703, and Annex 2. The person responsible for crew operations or agent for service must accept responsibility for complying with the stated regulations by signing this document. This document is considered invalid until signed. If the person signing this document relinquishes responsibility, changes mailing address, or the aircraft changes ownership or base of operation, this letter becomes invalid and the signee should immediately notify the issuing office of the change. LOA's can be renewed via letter or fax request submitted at least 30 days before the expiration date, if no changes have been made. If any changes have been made, application for a new LOA must be made in the same manner as that required for the initial LOA.

_____
Office Manager's Signature

APPENDIX 3. DOCUMENTATION REQUIRED TO COMPLETE THE APPROVAL PROCESS INFORMATION TO BE INSERTED ON THE BACK OF THE LOA

PRE-FLIGHT SPECIAL REQUIREMENTS: ***Note: Operators should list any procedures that are utilized which are pertinent to the accuracy and time limit of the navigation capability*** **(e.g., an approved Fault Detection and Exclusion (FDE) program is required if GPS is to be used - if utilizing a procedure detailed in an another FAA document, that document may be referenced and a copy attached to the application).**

_____
_____
_____
_____
_____

OTHER INFORMATION AS DEEMED NECESSARY BY THE ISSUING FLIGHT STANDARDS DISTRICT OFFICE:

_____
_____
_____
_____
_____
_____
_____

APPENDIX 3. DOCUMENTATION REQUIRED TO COMPLETE THE APPROVAL PROCESS

FORMAT FOR LETTER TO RENEW LOA

FROM: [*person or department requesting LOA*]
[*company name (if applicable)*]
[*street address*] (P.O. Box not acceptable)
[*city, state, zip code*]

TO: Federal Aviation Administration (FAA)
Flight Standards District Office
[*street address*]
[*city, state, zip*]

Dear Inspector:

Enclosed is a copy of our LOA, which is due to expire within the next 60 days, and a completed form requesting a new LOA for operations in Minimum Navigation Performance Specification and/or Reduced Vertical Separation Minimum airspace.

I/we further certify that all authorized crews are qualified to operate in oceanic areas.

Sincerely,

[*person's signature responsible for crew operations or agent for service*]
[*typed name of person responsible for crew operations or agent for service*]
[*title*]
[*date*]

NOTE: The letter should be sent to the office that issued expired LOA.

APPENDIX 4. TRAINING PROGRAMS AND OPERATING PRACTICES AND PROCEDURES

1. INTRODUCTION. The following items (detailed in paragraphs 2 through 5) should be standardized and incorporated into training programs and operating practices and procedures. Certain items may already be adequately standardized in existing operator programs and procedures. New technologies may also eliminate the need for certain crew actions. If this is found to be the case, then the intent of this appendix can be considered to be met.

2. FLIGHT PLANNING. During flight planning, the flightcrew should pay particular attentions to conditions which may affect operations in RNP-10 airspace (or on RNP-10 routes). These include, but may not be limited to:

a. verifying that the aircraft is approved for RNP-10 operations;

b. that the RNP-10 time limit has been accounted for (see paragraph 15);

c. verify that the letter "R" is annotated in Block 10 (Equipment) of the ICAO Flight Plan;

d. the requirements for GPS, such as FDE, if appropriate for the operation; and

e. if required for a specific navigation system, accounting for any operating restriction related to RNP-10 approval.

3. PREFLIGHT PROCEDURES AT THE AIRCRAFT FOR EACH FLIGHT. The following actions should be completed during preflight:

a. Review maintenance logs and forms to ascertain the conditions of equipment required for flight in RNP-10 airspace or on an RNP-10 route. Ensure the maintenance action has been taken to correct defects to required equipment.

b. During the external inspection of aircraft, particular attention should be paid to the condition of navigation antenna and the condition of the fuselage skin in the vicinity of each of these antenna (this check may be accomplished by a qualified and authorized person other than the pilot, e.g., a flight engineer or maintenance personnel).

c. Emergency procedures for operations in RNP-10 airspace or on RNP-10 routes are no different than normal oceanic emergency procedures with one exception, crews must be able to recognize and ATC advised when the aircraft is no longer able to navigate to its RNP-10 approval capability.

4. EN ROUTE.

a. At least, two Long Range Navigation systems capable of navigating to the RNP should be operational at the oceanic entry point. If this is not the case, then the pilot should consider an alternate routing which does not require that equipment or diverting for repairs.

b. Before entering oceanic airspace, the aircraft's position should be checked as accurately as possible by using external navigation aids (navaids). This may require distance measuring equipment DME/DME and/or DME/VHF omnidirectional (VOR) checks to determine navigation system errors through displayed and actual positions. If the system is updated , the proper procedures should be followed with the aid of a prepared checklist.

c. Operator in-flight operating drills shall include mandatory cross checking procedures to identify navigation errors in sufficient time to prevent aircraft from inadvertent deviation from ATC cleared routes.

d. Crews shall advise ATC of any deterioration or failure of the navigation equipment below the navigation performance requirements or of any deviations required for a contingency procedure.

5. FLIGHTCREW KNOWLEDGE.

a. Commercial Operators should ensure that crews have been trained to ensure that they are knowledgeable of the topics contained in this order, limits of their RNP-10 navigation capabilities, effects of updating and RNP-10 contingency procedures.

b. Part 91 operators should show the FAA that pilots are knowledgeable on RNP-10 operations. The intent is for an applicant for RNP-10 authorization to show the FAA that crew members are knowledgeable on the material contained in this order. FAA Order 8700.1, General Aviation Inspector's Handbook, Chapter 222, addresses training for part 91 operators. It states that specific training is not required by 14 CFR or by Annex 2 to the ICAO Rules of the Air and gives inspectors latitude in determining pilot qualifications. It further states that on the LOA, the statement, "Crew training conducted by" can be completed with an entry of: none, self, company training or the name of a commercial training course. Training "acceptable" to the FAA is not a prerequisite for issuing an RNP-10 authorization. It is also not a requirement that a part 91 operator provide a certificate of training that says it is FAA approved. What can be considered as acceptable for an operator to show that crews have adequate knowledge of the RNP-10 operating practices and procedures contained in this order is:

(1) FAA inspectors can accept training center certificates without further evaluation;

(2) FAA inspectors may elect to evaluate a training course before accepting a training center certificate from a specific center;

(3) FAA inspectors may accept a statement in the operator's application for an RNP-10 LOA that the operator has and will ensure that crews are knowledgeable of RNP-10 operating practices and procedures contained in this order; and

(4) FAA inspectors may accept a statement by the operator that it has conducted or will conduct an in-house RNP-10 training program.

APPENDIX 5. CHECKLIST AND JOB AID FOR THE RNP-10 APPROVAL APPLICATION PROCESS

OPERATOR FUNCTIONS:

1. OPERATOR PREPARES AN APPLICATION PACKAGE AS DESCRIBED IN PARAGRAPH 9 OF THIS ORDER.

2. OPERATOR SELF-EXAMINATION. It is advisable that operators become familiar with paragraphs 8 and 9 of this order before contacting the FAA. These sections provide the criteria for approvals by placing aircraft/navigation systems in groups. A knowledge of these sections provides the operator with an indication of how much time might be required in obtaining an approval. Group I approvals are administrative and can be granted as quickly as district office work loads will permit. Group II approvals may be made quite rapidly or may take longer depending upon the aircraft/navigation system configurations. Group III approvals will usually involve an extended time for evaluation and an approval may or may not be granted.

3. OPERATOR SCHEDULES A PREAPPLICATION MEETING. The operator schedules a preapplication meeting with either CHDO for commercial operators, or FSDO for general aviation.

4. OPERATOR SUBMITS A FORMAL APPLICATION FOR APPROVAL. The operator submits a formal application for approval in accordance with the FAA expectations discussed in the preapplication meeting. The formal application should be made in writing in a manner similar to those shown in appendix 3.

- Figure 1 for Air Carriers
- Figure 2 for General Aviation

5. OPERATOR TRAINS CREW. An RNP-10 airspace or an RNP-10 route is a special airspace. There are no legal requirements for general aviation operators to have specific training for RNP-10 operations; however, ICAO Rules demand that States ensure that the crew members are qualified to operate in special airspace. Thus, general aviation operators will be required to satisfy the Administrator that they are qualified.

6. OPERATORS RECEIVE OPERATION SPECIFICATIONS OR AN LOA. The operators receive operation specifications for an LOA to operate in an RNP-10 airspace or on an RNP-10 route.

7. CREWS ARE AUTHORIZED TO PERFORM RNP-10 OPERATIONS. Crews are authorized to perform RNP-10 operations for the time authorized within the parameters established for their navigation system configuration.

INSPECTOR FUNCTIONS:

See Job Aid on the next page.

INSPECTOR'S JOB AID

PTRS CODE	APPLICANT_____	Para & Pg	INSP INIT.	DATE
	1. Inspector familiarization with the approval process	Para 8 Pg 3		
1366	**2. Set up applicant meeting date**	Para 8a Pg 3		
1366	**3. Application meeting:** **Inspector_____** Applicant orientation to FAA Order 8400.12A Check of Documentation -RNP time requested for specific route system or area of operation -Airworthiness documentation -Current Operation Specifications, if applicable -Current Letter of Authorization, if applicable -Copy of pertinent sections of the Airplane Flight Manual -List of number and type of Long Range Navigation Units (e.g., 3- Litton 92, INS) -Description of Long Range Navigation System integration. -Description of updating procedures, if used -Review of training program -RNP-10 Operations Issues -RNP-10 Contingency Procedures -Updating Procedures and Implications of the Update on the Navigation Solution (if updating is planned)	Para 8a Pg 3		
	3. Evaluate Operator's Long Range Navigation System - Determine Eligibility Group Choose one of the following as a means by which approval will be accomplished: -The operator has an Airplane Flight Manual (AFM) entry or other documentation from an FAA Aircraft Certification office granting certification approval for RNP-10 or better for a specific time period (eligibility group 1) -Plan on approving the operator for unlimited RNP-10 navigation if either one or both of the required Long Range Navigation Systems is a GPS and the unit(s) are integral to the primary steering instrument of the mandatory flightcrew. GPS approval guidance is contained in HBAT 95-09 and FAA Notice 8110.60 -Approve the operator for the RNP value and time specified in the AFM -Approve the operator for RNP-10 for 6.2 hours based upon the "/E" suffix as defined in the AIM and qualifications that meet	Para 12 Pg 7 Para 12a Pg 8		

INSPECTOR'S JOB AID (Continued)

PTRS CODE		Para & Pg	INSP INIT	DATE
	3. Evaluate Operator's Long Range Navigation System (continued) Title 14 CFR Part 121, Appendix G (eligibility group 2) ask operator if approval of additional time will be needed - if yes, then a discussion of one of the extended time procedures will be required -Require that operational navigation performance data be presented (eligibility group 3) -Determine if the operator has updating procedures. If yes, then the procedures for its use must be contained in the training curriculum and crews must be knowledgeable in its use and its effect on the navigation solution. If no, then; -Advise operator that a data collection program based on one of the following will be required prior to granting approval (eligibility group 3) -Sequential sampling based on Appendix 1 of FAA Order 8400.12A -Periodic data collection based upon a portable GPS being used for a base-line (see Appendix 6) or data collection based upon the radial error determined from destination gate positions	Para 12b Pg 8 Para 12c Pg 9 para 121d and 12e Pg 10 Appendix 1 Appendix 6		
	4. Data Analysis Meeting -Check all data required and discussed at the application meeting -Be especially aware that the documentation is consistent with the equipment actually installed in the aircraft -Check training curriculum or in the case of general aviation operators, the knowledge of the person endorsing the crew knowledge section of the LOA -If data collection was required, examine it closely. If any doubt exist as to the validity or integrity of the data, contact one of the navigation specialists or AFS-400 at Washington headquarters	Appendices 1 and 6 Appendix 4		

INSPECTOR'S JOB AID (Continued)

1442	**5. Issue operation specifications or an LOA* to the operator.**			
1442	**6. Complete a Program Tracking and Reporting System (PTRS) report noting the issuance of the RNP-10 authorization for a specified time** -The National Use Field is a 9 space Alpha Numeric Field. The following entry must be made in the field: "RNP-10" followed by 3 spaces.			

* ***Note*** *FAA Order 8700.1, chapter 222, Guidance for the Issuance of a Letter of Authorization, provides the ASI with details relative to the issuance of an LOA.*

APPENDIX 6. A SAMPLE DATA COLLECTION PROCESS (PERIODIC METHOD)

1. INTRODUCTION.

a. This section describes data collection procedures that have been approved by AFS-400 on the basis of analysis of the data and multiple validation flights. There are two methods in which data may be collected. One procedure is based upon the use of a handheld Global Positioning System (GPS) as a baseline for the correct position determination with the GPS readings and the data collection being taken by a non-essential flightcrew member. Only authorized flightcrews may operate the navigation system. Although no technical specifications are stated for the GPS unit used, it behooves operators to use the best quality unit that is practical. Poorer quality units might malfunction or provide erroneous data that will distort or negate the data collected and make the process excessively expensive. The second method uses a single, un-updated gate position as a data point and performing the calculations at the end of this appendix to determine an RNP-10 limit.

b. It is possible to evaluate triple-mix, individual units or both using this data collection procedure, the data collection forms are designed for this purpose. Operators desiring to use gate position only, do not need to use the data pages but can go directly to the destination data page and record the gate position data and time since last update.

2. GENERAL INSTRUCTIONS.

a. GPS Updating. Pilots are requested not to update the INS to a GPS position. Doing so would invalidate the data collected.

b. Data Recording. When recording data, all times are Universal Coordinated Time (UTC). Circle latitude and longitude senses (N or S, E or W). Please record any additional information that could be helpful in analyzing recorded data.

c. Page Heading. Complete all sections of the heading **ON EACH PAGE**. This is important in the event that pages become separated and get mixed with data from other flights.

d. INS Initialization. (Page 1 of DATA PAGES following this section.)

(1) Record any unusual movement of the airplane during INS initialization before NAV mode selected, such as wind gusts, or an airplane service vehicle bumping the airplane, or settling during fueling.

(2) If there was any unusual movement during INS alignment, record INS track (TK / GS) after NAV mode is selected.

(3) Record the published gate coordinates and/or GPS position where the INS is initialized.

(4) Was triple-mix selected? Check yes or no.

(5) Check if updating is by radio navigation of position, yes or no.

e. Times. (Page 1 of DATA PAGES following this section.)

(1) Before departure, record the time the pilots are observed putting the INS NAV mode selectors in NAV.

(2) Record OFF time.

(3) Record the time leaving class II navigation when radar contact is first established.

(4) Record IN (at the gate) time.

f. Destination Gate Positions. (Pages 4 and 5 of the DATA PAGES following this section.)

(1) Request that pilots not remove INS updates until INS updated / triple-mix positions are recorded at the gate.

(2) Record the destination gate number, published position, the number of GPS SV's (Satellite Vehicles) in view, GPS DOP and EPE values, and GPS position.

(3) Record INS updated / triple-mix positions.

(4) Remove INS updates.

(5) Record INS un-updated positions and INS distances from the gate position.

(6) INS data should be recorded in the Maintenance Log as usual.

g. 1/2 Hourly Position Readings. (Page 2 and beyond of data pages following this section.)

(1) Once each 30 minutes after takeoff (ACARS OFF time), plus or minus 5 minutes, record GPS and INS positions. Do not record data during climb or descent, during pilot INS Waypoint Change procedures or at other times when pilots obviously are busy with other tasks, such as ATC or cabin communications.

(2) Record the desired track (DSRTK/STS) of steering INS.

(3) Record the last and next waypoints lat/long and name.

(4) Freeze the GPS and INS positions simultaneously.

(5) Record GPS position.

(6) Record INS updated / triple-mix positions (HOLD and POS selected).

(7) Record the INS un-updated (Inertial) positions. (HOLD and WAY PT, thumbwheel other than 0 selected).

(8) Release the frozen INS and GPS positions.

h. En Route INS Updates. Use this section only if manual updating is being evaluated.
NOTE: There is no data sheet example for radio navigation updates.

(1) Record the identifier of the navaid over which updating is accomplished and the navaid coordinates.

(2) Record the number of GPS satellites in view and the GPS PDOP value.

(3) Record the time when INS coordinates are frozen before the en route update is accomplished.

(4) After INS positions are frozen and BEFORE AN UPDATED POSITION IS ENTERED.

(5) Record the INS updated / triple-mix positions and INS un-updated positions.

(6) Record the GPS position.

i. Radio Navigation INS Updates. Use this section only if manual updating is being evaluated (e.g., ground based radio navigation positions are used for INS updates); record:
NOTE: There is no data sheet example for radio navigation updates.

(1) Navaid identifiers.

(2) Aircraft position derived from ground navaids (update position).

(3) Time of update.

(4) INS position before update.

(5) GPS position.

DATA PAGES

Flight No. _____ UTC Departure Date _____ Departure Airport _____

Aircraft Type. _____ Registration No. N_____ Arrival Airport _____ Captain _____

INS INITIALIZATION

Were there any unusual motion events during alignment? Yes _____ No _____
If yes, INS Track (TK / GS)

If yes, provide a brief description of the event(s): _____

_____

_____

INS initialization coordinates (published or GPS): N / S

E / W

Triple-mix selected? Yes _____ No _____

Radio navigation updating? Yes _____ No _____

TIMES

	Z	OFF
	Z	Time NAV mode selected
hrs.	mins.	Time in NAV mode before takeoff
	Z	Time entering Class II nav airspace
	Z	Approx time leaving Class II nav airspace
	Z	Time NAV mod selected
hrs.	mins.	Approx time in NAV mode before leaving Class II airspace
	Z	IN
	Z	Time NAV mode selected
hrs.	mins.	Total time in NAV mode

DATA PAGES

Flight No. _____ UTC Departure Date _____ Departure Apt _____

Plane No. _____ Registration No. N_____ Arrival Apt _____ Captain _____

DATA POINT 1	**Z**		**Altitude**	
GPS	No. of SV	DOP	EPE	
GPS Position	N/S		E/W	
Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/S E/W
NEXT WAYPOINT		NAME		N/S E/W

DATA POINT 2	**Z**		**Altitude**	
GPS	No. of SV	DOP	EPE	
GPS Position	N/S		E/W	
Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/S E/W
NEXT WAYPOINT		NAME		N/S E/W

DATA PAGES

Flight No. _____ UTC Departure Date _____ Departure Airport _____

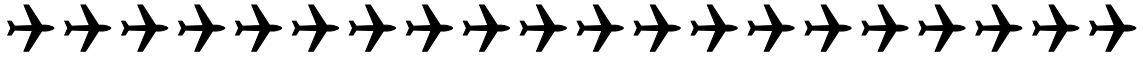
Aircraft Type. _____ Registration No. N_____ Arrival Airport _____ Captain _____

DATA POINT 3	**Z**	**Altitude**		
GPS	No. of SV	DOP	EPE	
GPS Position	N/S		E/W	
Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/S E/W
NEXT WAYPOINT		NAME		N/S E/W

DATA POINT 4	**Z**	**Altitude**		
GPS	No. of SV	DOP	EPE	
GPS Position	N/S		E/W	
Triple-Mix Positions			Un-Updated Positions	
		INS 1		
		INS 2		
		INS 3		
LAST WAYPOINT		NAME		N/S E/W
NEXT WAYPOINT		NAME		N/S E/W

Flight No. _____ UTC Departure Date _____ Departure Apt _____

Plane No. _____ Registration No. N_____ Arrival Apt _____ Captain _____



NOTE: Copy previous pages for use in collecting data points in excess of 4 as needed to collect data for the total flight hours. Use the procedures following the destination data pages to analyze the data.

COMPLETE DESTINATION DATA ON NEXT PAGE

DATA PAGES

Flight No. _____ UTC Departure Date _____ Departure Airport _____

Aircraft Type. _____ Registration No. N_____ Arrival Airport _____ Captain _____

DESTINATION GPS / INS POSITIONS

Please do not remove INS updates until up-dated / triple-mix positions are recorded at the gate.

Destination Gate No.

PUBLISHED POSITION --------> N/S E/W

GPS	No. of SV	DOP	EPE
GPS Position	N/S	E/W	

Triple-Mix Position	Un-Updated Positions	Distance
[redacted]		

Name of person recording data (Please print): _____

Position: _____ Company Location: _____

Telephone No. (Business and home): _____

3. RNP-10 DATA REDUCTION TECHNIQUES FOR PERIODIC, IN-FLIGHT, METHOD OF DATA COLLECTED.

a. Collect reference data (GPS) and INS/IRU data at least every 30 minutes after reaching initial cruise altitude. (Lat, Long, Height and time at the same time for each system.)

b. Determine North-South and East-West error in NM. (Difference between GPS and INS/IRU position translated into NM.)

c. Graph position error (using GPS as reference) vs. time for each flight.

d. Since the actual time of measurement and the test time interval will vary, establish on each flight chart (plot) an equally spaced interval.

e. At each time interval, calculate the radial position error for each flight. (This requires interpolation of the North-South, East-West data from the graphs.)

f. This radial error is the data used to determine the 95 percentile level of error. "The 95 percentile error level of error" is used here to mean that it is 95 % probable that the error in a given flight will fall below this level or that the level will be below this level in 95% of flights if the number of flights is very large.

g. After collecting the data for all flights, calculate the root-mean-square (RMS) and Geometric Mean (GM) of the radial errors For each elapsed time point. Also determine the ratio of GM/RMS for each elapsed time point.

$$RMS = \left(\frac{1}{n} \sum_{i=1}^{i=n} r_i^{\,2} \right)^{1/2}$$

$$GM = \left(\prod_{i=1}^{i=n} r_i \right)^{1/n}$$

where:

r = radial error at elapsed time point

n = number of observations of radial error at equally spaced time intervals

h. Using the P=95 curve from the figure 1 on page 10, find the value of $r_{(P)}$/RMS for the calculated value of GM/RMS. Multiply this $r_{(P)}$/RMS factor by the value of RMS to determine an estimate of the 95th percentile value of radial error at this elapsed time point.

i. Repeat the above procedure for each elapsed time point. Graph $r_{(95)}$ values of radial error (in NM) vs. elapsed time since entering the NAVIGATE mode.

j. Pass-Fail Criteria. The elapsed time when radial error $r_{(95)}$ exceeds 10 NM defines maximum flight time wherein the navigation system meets RNP-10 criteria.

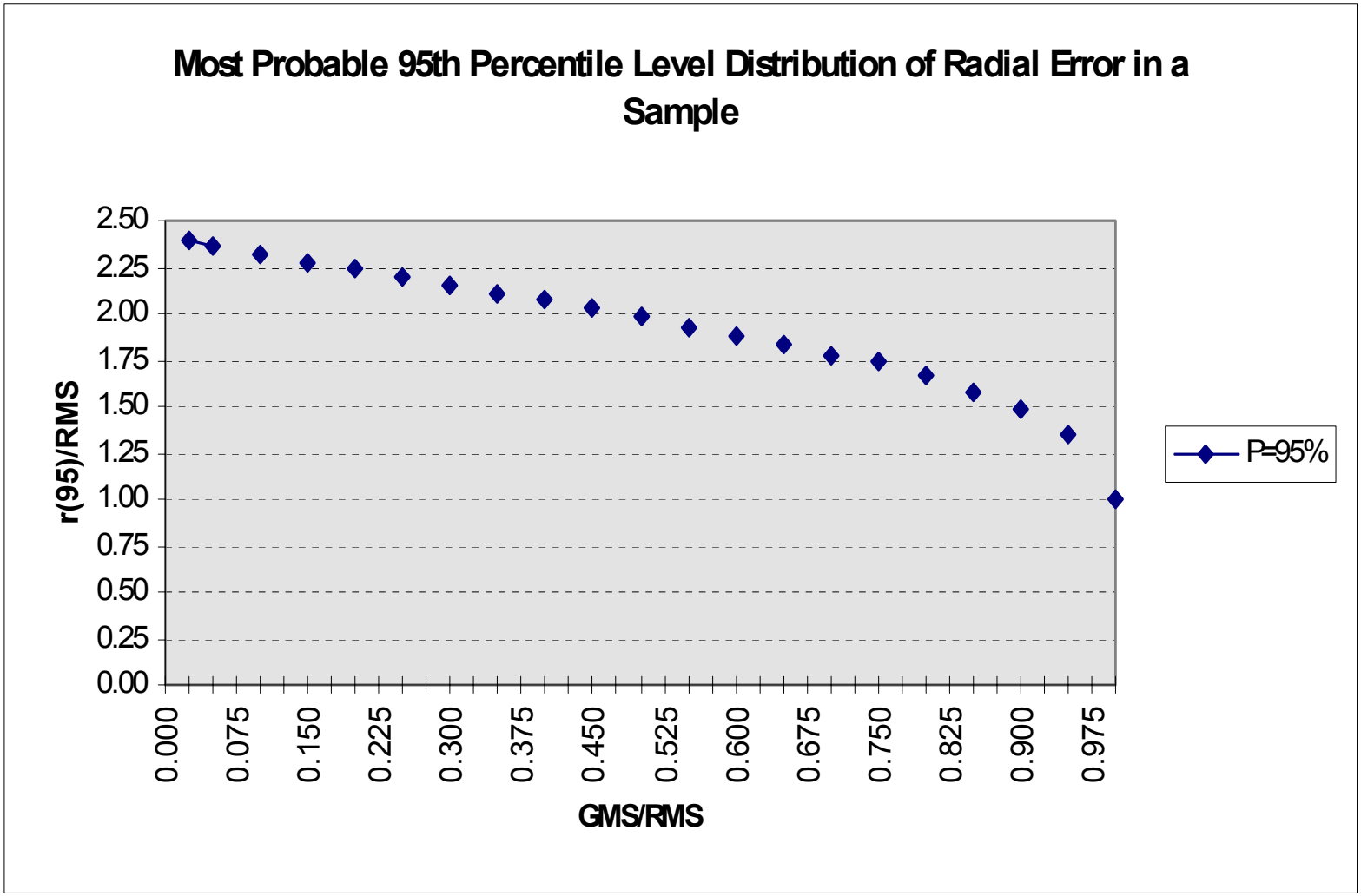

Most Probable 95th Percentile Level Distribution of Radial Error in a Sample
r(95)/RMS
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.000
0.075
0.150
0.225
0.300
0.375
0.450
0.525
0.600
0.675
0.750
0.825
0.900
0.975
GMS/RMS
P=95%

Figure 1

4. PERIODIC METHOD EXAMPLE. For an example, a 6 flight data set is used (in actual practice a much larger data set should be used to provide confidence). For simplicity of illustration, this example uses only the Triple-Mix positions after 10 hours in nav (the time was an arbitrary selection to illustrate the means of calculation). Data for individual navigation units is not included in this example; if they had been used, they would be calculated in exactly the same manner that the Triple-Mix data is calculated in the example. If an operator decided to use gate position, only Figure 2 should be used.

Symbols Used in figures below:

r = radial error

r^2 = square of the radial error

IIr = product of radial errors

$\sum$ = Sum

$\sum r^2$ = Sum of the squares of the radial errors

Figure 1. Table of Radial Errors "r" (Use for airborne data collection)

Flight	radial errors = r	r^2
1	6.5	42.25
2	5.5	30.25
3	12.7	161.22
4	14.0	196.00
5	7.2	51.84
6	7.0	49.00

The product (**II**) of radial errors (column 2) = 320,360

The sum of the radial errors squared ($\sum r^2$) (column 3) = 530.63

Calculations:

$$RMS = \left(\frac{1}{n} \sum_{i=1}^{i=n} r_i^{\,2} \right)^{1/2} = (1/6\ (530.63))^{1/2} = 9.40$$

$$GM = \left(\prod_{i=1}^{i=n} r_i \right)^{1/n} = (320.36)^{1/6} = 8.27$$

RATIO = GM/RMS = 8.27/9.40 = 0.88

Find this value (0.88) on the abscissa of the "Most Probable Graph" and intersect it with the 95% curve to find $r_{(95)}$ /RMS (on the ordinate of the graph)

thus $r_{(95)}$ /RMS = 1.47 (for this example)

The ordinate is defined as $r_{(95)}$ /RMS

where $r_{(95)}$ = 95 percentile of error

Now $r_{(95)}$ for the data in the example is determined from the following:

$r_{(95)}$ = Ordinate value (for the data) x RMS = 1.47 x 9.40 = 13.8 NM

These results indicate:

The 95 percentile level of error at 10 hours is 13.8 NM which is greater than the required 10 NM and the system would not qualify for RNP-10 for 10 hours based on the data presented.

For guidance on gate position data collection, go to next page.

Figure 2. Table of Radial Errors (Use for gate position data)

Note: No data is provided for this method. Calculations would be made identical to the procedure used in Figure 1.

Time is critical with this set of data and it should be noted that the credited time is that of the smallest time value in the data set.

Flight	Times since last update	Radial Error at Gate = r	r^2

(1) The product (**II**) of radial errors (column 3) = _____

(2) The n^{th} route of **II** = _____ = GM

(3) The sum of the radial errors squared ($\sum r^2$) (column 4) = _____

(4) The square route of $\left(\frac{1}{n} \sum r_i^2 \right)$ = _____ = RMS

After calculating (2) and (4) use figure 1 on page 10 to determine $r_{(95)}$. Multiply this factor by the RMS to determine the drift in NM. If this value is less than 10 NM then the navigation system can be approved for RNP-10 for the time in nav of this flight. Note that this is the data for one flight only, data must be collected in the same manner and in an equal time length for a minimum of 20 flights.

APPENDIX 7. AN APPROVED MANUAL UPDATING PROCEDURE

Manual Updating for RNP-10 Operations

1. INTRODUCTION. In order to facilitate RNP-10 operations for airborne navigation systems that are unable to achieve RNP-10 performance for greater than 6.2 hours, the following methods of manual position updating are suggested as a means to extend the 6.2 hours. Manual position updating is defined to mean a technique where the crew uses one of the techniques, described below, to adjust their INS output to compensate for the detected error. The detected error is the difference between the radio navigation position and the INS/IRU position with the radio navigation position being considered the correct position.

Two techniques using VOR/DME or TACAN and one technique using a Global Positioning System are possible means of manual updating. The first is a position update based on crossing a fix along a route defined by a bearing and distance from/to a VOR/DME or TACAN facility. The second is based on a route that flies over a VOR/DME or TACAN facility. The third is similar to the first but uses a TSO C-129 GPS receiver with an approved installation for the update in place of a navigation aid. In each of the three methods, a log (the plotting chart used in each of the procedures is an acceptable log if all required data is entered on the chart) of the procedure must be made of the data and maintained by the operator for a period of 30 days. The conditions under which either method may be used are as follows:

a. Class II Inertial Navigation Systems meeting 14 CFR, part 121, appendix G requirements or the criteria established in Advisory Circular 25-4, Inertial Navigation Systems (INS).

b. For the first and second methods the minimum distance from the reference VOR/DME facility must be at least 50 nautical miles.

c. Both the VOR and DME functions of the reference facility must be operational prior to dispatch release and during the intended updating operation unless the GPS procedures is used as a reference.

d. The flightcrew must have in its possession a plotting chart with the information specified in this Appendix.

2. MANDATORY DATA REQUIRED TO ACCOMPANY ALL OF THE UPDATING METHODS (Required for Each Flight along with Copy of the Plotting Chart).

INS INITIALIZATION

Were there any unusual motion events during alignment? Yes _____ No _____
If yes, INS Track (TK / GS)

If yes, provide a brief description of the event(s): _____

_____

INS initialization coordinates (published or GPS): N/S E/E

Triple-mix selected? Yes _____ No _____

Radio navigation updating? Yes _____ No _____

TIMES

PRIOR TO TAKEOFF

_____Z OFF

_____Z Time NAV mode selected

_____hrs. ___mins Time in NAV mode before takeoff

FLIGHT PHASE

_____Z Approx time leaving Class II nav airspace

_____Z Time NAV mod selected

_____hrs. ___mins Approx time in NAV mode before leaving Class II airspace

ARRIVAL PHASE

_____Z IN

_____Z Time NAV mode selected

_____hrs. __mins Total time in NAV mode

3. TRAINING.

a. Commercial operators intending on using manual updating procedures must ensure that every flightcrew using the procedures is trained in the updating procedures. The operator should be able to demonstrate that it has a reliable method of having its crews perform the update, and can be approved by the operator's POI to determine if the method is acceptable. Training manuals must be updated to include the procedures and will be evaluated by the POI as a part of the approval process.

b. General aviation operators intending on using manual updating procedures must provide evidence to the approving office that crews using the procedures are capable of maintaining the same standards as commercial operators.

4. METHOD 1: MANUAL UPDATING BASED ON CROSSING A FIX ALONG A ROUTE.

a. Using Method 1, the update is performed when crossing over a fix that is defined by a crossing radial and distance from a VOR/DME or TACAN facility. To accomplish this update, the crossing radial must be at or near perpendicular to the route. The minimum DME /TACAN distance used to define the fix location shall be at least 50 NM.

b. The flightcrew should tune in the reference VOR/DME or TACAN facility and pre-select the appropriate bearing on one CDI. As the CDI centers, the flightcrew will note the distance from the VOR/DME or TACAN facility and mark it on the plotting chart. The flightcrew will also note the inertial positions of each of the operating INS. The crew will then compare the inertial position against the derived position. The crew then may use the derived position (expressed in lat/long) to update the inertial position. If interpolation is necessary, round up. This procedure would provide a means to re-start the RNP-10 clock for an additional predetermined time.

c. To accomplish this manual update, the flightcrew should have a plotting chart that displays the route fix and DME fixes of one-mile increments located along a line that is perpendicular or near perpendicular to the route along the axis of the VOR/TACAN radial used to define the fix. Each fix should be displayed in both DME distance and latitude/longitude coordinates.

d. Put two fixes along the route, one on either side of the "update," fix and note the coordinates on the plotting chart. Crews should then use these fixes to validate the position update. This is similar to the method used for updating when flying on a route that passes over a VOR/DME or TACAN facility. It is imperative for crews to remember that these additional fixes are to be used for verification only, not as an update fix. They do, however, provide a means of verification of the update.

NOTE: This type of manual updating would be applicable when operating along several of the routes that pass in the vicinity of SHEMYA VOR such as R220, W460, R-341, A-590, A-342, R-451 and R-336.

5. METHOD 2: MANUAL UPDATING WHEN FLYING A ROUTE THAT IS DEFINED BY A VOR/DME OR TACAN FACILITY.

a. The accuracy of a manual update when over flying a VOR/DME or TACAN facility is questionable due to the "cone of confusion" that exists overhead the facility and varies as a function of the altitude of the aircraft. To increase the accuracy of a manual update in this situation, it is recommended that a plotting chart be created that has fixes depicted along the route at a minimum distance of 50 NM, but not more than 60 NM from the VOR/DME or TACAN. These fixes should display the bearing and distance and the latitude/longitude coordinates expressed to a tenth of a degree. The specified distances will account for slant range error and radial width.

b. In this situation, the suggested procedure would be for the flightcrew to discontinue INS navigation when receiving the VOR/DME or TACAN signal and attempt to align the aircraft exactly on the desired radial to or from the station. When passing over the specified fix, the crew will compare each of the INS positions with the reference lat/long position of the fix. The manual update should be attempted if the along track position error is greater than 1 NM. After the manual update is completed, the crew should continue to navigate by the VOR radial to the next designated fix and compare the coordinates to verify that the update was successful.

c. As minimum requirements for use of these procedures, the crew must have on board the appropriate plotting charts with the specified information, and the operator must demonstrate that its crews know how to use the charts and procedures.

d. These procedures should be based on the assumption that triple mix position fixing is not used, and each inertial must be updated accordingly. The crew must notify ATC anytime it becomes aware that the aircraft can no longer maintain RNP-10 performance based on evaluation of the position checks.

6. METHOD 3: USING AN IFR APPROVED GPS INSTALLATION AS AN UPDATING REFERENCE.

a. Using Method 3, the update is performed by comparing the INS position to the GPS position at a chosen way point.

b. Prior to departure the mandatory data must be logged.

c. Updating

(1) Record the time when INS coordinates are frozen before the en route update is accomplished and the flight level.

(2) Record the number of GPS SV's (Satellite Vehicles) locked on and the GPS DOP and Estimated Position Error (EPE) values.

(3) Record the desired track (DSRTK / STS) of the steering INS.

(4) Freeze the GPS and INS positions simultaneously.

(5) From the data determine the approximate amount of drift per hour flown, make appropriate corrections and continue to navigate.

(6) If data indicates that RNP-10 capability is impossible to maintain, Air Traffic must be notified as soon as flight conditions will permit.

d. Completion of Class II Navigation and Post Flight: This step is important in that it verifies the accuracy of the updating process and will warn operators if their is an equipment or procedural problem that might effect future flights. Additionally, this information can be used in a

response to an Overseas Navigation Error Report (ONER).

(1) Record the time leaving Class II Navigation when radar contact is first established or when first within 150 NM of a VOR navaid, Record IN time.

(2) Destination Gate Positions: Do not remove INS updates until updated INS is recorded at the gate.

(3) Record the destination gate number, the number of GPS SV's (Satellite Vehicles) in view and the GPS DOP and EPE values.

(4) Record updated INS positions.

(5) Remove INS updates.

(6) Record INS un-updated positions and INS distances from the gate position.

(7) Record GPS position. If GPS position is unavailable, record the gate position (FOM airport 10-7 page or airport plan view).

(8) INS data should be recorded in the Maintenance Log as usual.

(9) Release the frozen INS positions.

Appendix 8

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INDEX (continued)

Appendices